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SEASONAL SUCCESSION AND DIVERSITY OF STONEFLIES (PLECOPTERA) IN FACTORY BROOK, MASSACHUSETTS[1]

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Abstract.—Neves, Richard J., Massachusetts Cooperative Fishery Research Unit, Department of Forestry and Wildlife Management, University of Massachusetts, Amherst, Massachusetts 01003. Present address of author: Virginia Cooperative Fishery Research Unit, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.—The species composition and flight periods of Plecoptera along a woodland stream in Massachusetts was studied by 3 yr of nymphal and adult sampling. Twenty-two genera and 45 species emerged between mid-February and early September. Most species were collected in May and June at stream temperatures between 8–15 C. A comparison with other stonefly surveys indicated a diversity gradient for Plecoptera in North America.

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Introduction

During initial productivity studies in a Massachusetts woodland stream, stoneflies exhibited considerable diversity in the benthic community and constituted a major component of the invertebrate trophic structure. A literature review revealed extensive taxonomic studies on the Plecoptera of New England but little ecological data on the diversity and seasonal progression of species from one stream. Stonefly surveys on specific streams have been published for several regions of the U.S. (Knight and Gaufin 1966; Sheldon and Jewett 1967; Hilsenhoff et al. 1972; White 1974; Ellis 1975; Kerst and Anderson 1975) but not for the Northeast. This paper summarizes 3 yr of nymphal and adult stonefly collections along Factory Brook and presents the species composition and appearance of adults throughout the year.

Study Area

Factory Brook (lat. 42°20′64″N, long. 73°00′95″W) is a 13 km tributary of the West Branch, Westfield River in Hampshire County, western Massachusetts. The stream drains 2,204 ha and has a gradient of 18.6 m/km. Base flow during late summer averages 0.004 m^3/s; mean annual precipitation for the region is 114 cm/yr. Soil composition is shallow glacial tills underlaid by gneiss bedrock. Land use in the drainage basin is as follows: woodland 90%, cropland and pasture 8%, wetland 1%, and urban land 1% (MacConnell 1975). The woodland is a typical mixed northern hardwood and eastern hemlock forest providing a canopy over most of the stream. Fish species composition is typical of trout streams in the Northeast (Enoch 1976).

Stream sediments are predominantly coarse particle sizes ranging from pebbles to boulders; bedrock outcrops occur at intervals downstream. The stream does not freeze over in winter, although ice shelves nearly cover pools and slow riffles; frazil ice is common in February. Mid-monthly physico-chemical analyses of water parameters during 1974 yielded the following ranges: temperature (0–19.5 C), discharge (0.004–2.6 m^3/s), dissolved oxygen (9–12 mg/l), total hardness (14–24 mg/l), and pH (6.5–7.5).

Materials and Methods

Stonefly nymphs and adults were collected along accessible sections of Factory Brook from September 1973 to June 1976. I captured adults by aerial net, aspirator, forceps, and blacklight insect-trap. Examination of bridge abutments, railings, and snow crests during winter and spring, and tri-weekly sweepnet collections in riparian vegetation from May to September, 1974 and 1975 proved effective for most species. Weekly blacklighting for 1 h after dusk was conducted from May to September 1975.

Emerging nymphs were captured by spreading Stikem Special (Michel and Pelton Co., Emeryville, Calif.), a non-drying adhesive, above the waterline on two bridges over the stream. I reared last instar nymphs in screen cages in the stream and laboratory. Monthly benthic samples obtained by Surber sampler, D-frame net, or periodic sets of rectangular drift nets (30 × 45 cm) were sorted and identified to supplement adult collection records. Water temperature was monitored for two consecutive years with a Ryan Model D-30 recording thermometer.

All insects were preserved in 70% isopropanol. Species identifications were based on the keys of Frison (1935, 1942), Ricker (1952), Hitchcock (1974), Baumann (1975), Ricker and Ross (1975), and Stark and Gaufin (1976); nomenclature followed Illies (1966) and Zwick (1973).

Results

The stonefly fauna of Factory Brook totaled 45 species and included nine families and 22 genera (Table 1); nymphs for 17 of these genera (77%) were collected in benthic samples. Two species, *Perlinella drymo* and *Amphinemura wui,* were taken only as nymphs. I captured nearly 5,000 adults and many more immatures during this survey, but collections of some females and nymphs could not be identified to species. Six species were represented by single male specimens, *Ostrocerca truncata, O. complexa, O. albidipennis, Prostoia similis, Isoperla clio,* and *Perlesta placida.* Perlids and perlodids were occasionally taken by light-trap, while other families were rarely attracted to the blacklight. I collected most perlids and *Allonarcys biloba*

Table 1. Checklist of Plecoptera collected along Factory Brook, September 1973 to June 1976.

Pteronarcidae
Allonarcys biloba (Newman)
Peltoperlidae
Peltoperla maria Needham & Smith
Taeniopterygidae
Taenionema atlanticum Ricker & Ross
Oemopteryx contorta (Needham & Claassen)
Taeniopteryx maura (Pictet)
Leuctridae
Leuctra ferruginea (Walker)
Leuctra grandis Banks
Leuctra sibleyi Claassen
Leuctra tenella Provancher
Leuctra tenuis (Pictet)
Paraleuctra sara (Claassen)
Capniidae
Allocapnia maria Hanson
Allocapnia minima (Newport)
Allocapnia nivicola (Fitch)
Allocapnia pygmaea (Burmeister)
Paracapnia angulata Hanson
Nemouridae
* *Amphinemura wui* (Claassen)
Ostrocerca albidipennis (Walker)
Ostrocerca complexa (Claassen)
Ostrocerca truncata (Claassen)
Prostoia completa (Walker)
Prostoia similis (Hagen)
Chloroperlidae
Alloperla atlantica Baumann
Alloperla caudata Frison
Alloperla chloris Frison
Alloperla concolor Ricker
Alloperla voinae Ricker
Hastaperla brevis (Banks)
Sweltsa lateralis (Banks)
Sweltsa mediana (Banks)

Table 1. Continued.

Perlodidae
Isogenoides hansoni (Ricker)
Isoperla bilineata (Say)
Isoperla clio (Newman)
Isoperla cotta Ricker
Isoperla dicala Frison
Isoperla francesca Harper
Isoperla holochlora (Klapalek)
Isoperla lata Frison
Isoperla similis (Hagen)
Perlidae
Acroneuria abnormis (Newman)
Acroneuria carolinensis (Banks)
Paragnetina immarginata (Say)
Perlesta placida (Hagen)
* *Perlinella drymo* (Newman)
Phasganophora capitata (Pictet)

* Collected only as nymphs.

adults from bridge and railing cracks bordering the stream; sweepnet and aspirator were effective on the remaining species.

Water temperatures were lowest in February (0 C) and highest in late July (21.5 C) (Figure 1). Winter species emerged over several weeks on days when water and air temperatures were slightly above freezing. Emergence of spring species corresponded with a gradual rise in water temperature during late March and April. The greatest number of species was collected in May and June at stream temperatures between 8 C and 15 C.

Adult stoneflies first appeared in mid-February, with a progression of species emerging into September (Figure 2). Discontinuous collections of a species (3 wk or less) were attributed to sampling inefficiency and not adult absence. Seasonal occurrence of the various forms ranged from 1 wk to 12 wk. Prolonged flight periods were evident for *Leuctra ferruginea*, *L. tenuis*, *Paragnetina immarginata*, *Alloperla chloris*, *A. caudata*, *Taeniopteryx maura*, and *Allocapnia* spp. Emerging nymphs of *Allocapnia*, *Alloperla*, and *Isoperla* showed considerable congeneric overlap. Collections of nymphs and exuviae on the non-drying adhesive indicated that times of individual species emergence were within 5 days of each other in 1974 and 1975. The

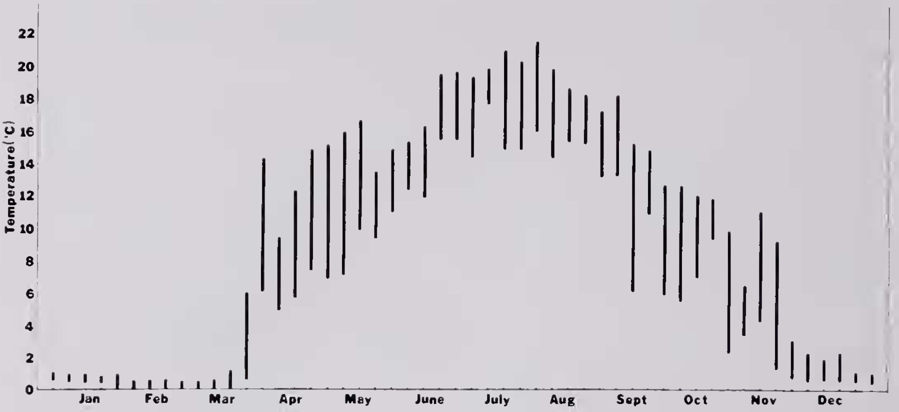

Figure 1. Combined weekly range of water temperatures for Factory Brook, September 1973 to August 1975.

relative abundance of species, based on adults and identifiable nymphs was as follows (Figure 2): 9 abundant (A), 14 common (C), 11 uncommon (U), and 11 rare (R).

Discussion

Sampling problems due to seasonal availability and distribution of nymphs and adults were overcome by the prolonged period and multiple sampling methods used in this survey. The alternative sampling approach, extensive use of emergence traps, can theoretically collect representatives of all species emerging from a stream and eliminate potential immigrants from collections. However, the advantages and disadvantages of emergence traps should be evaluated prior to field use (Gledhill 1960; Harper and Pilon 1970; Langford and Daffern 1975). The years of collecting required to obtain a relatively complete list of organisms from one stream (Cummins 1975) is indicative of the sampling difficulty in evaluating aquatic insect diversity.

The longitudinal zonation and life cycle differences among species (Minshall 1968; Hynes 1971; Woodall and Wallace 1972) required stratified sampling for an extended period to collect all nymphs present. For example, winter and early spring species remain in the egg or diapause stage for several months (Harper and Hynes 1970) and were not collected in my benthic samples from June to September. Considerable sampling effort was also required to obtain adults of all species, since they were seldom taken by light-trap and have limited dispersal ability. The greater longevity of females (Finni 1975; Lillehammer 1975) and the relatively long egg development period for many species greatly extended the flight period of fe-

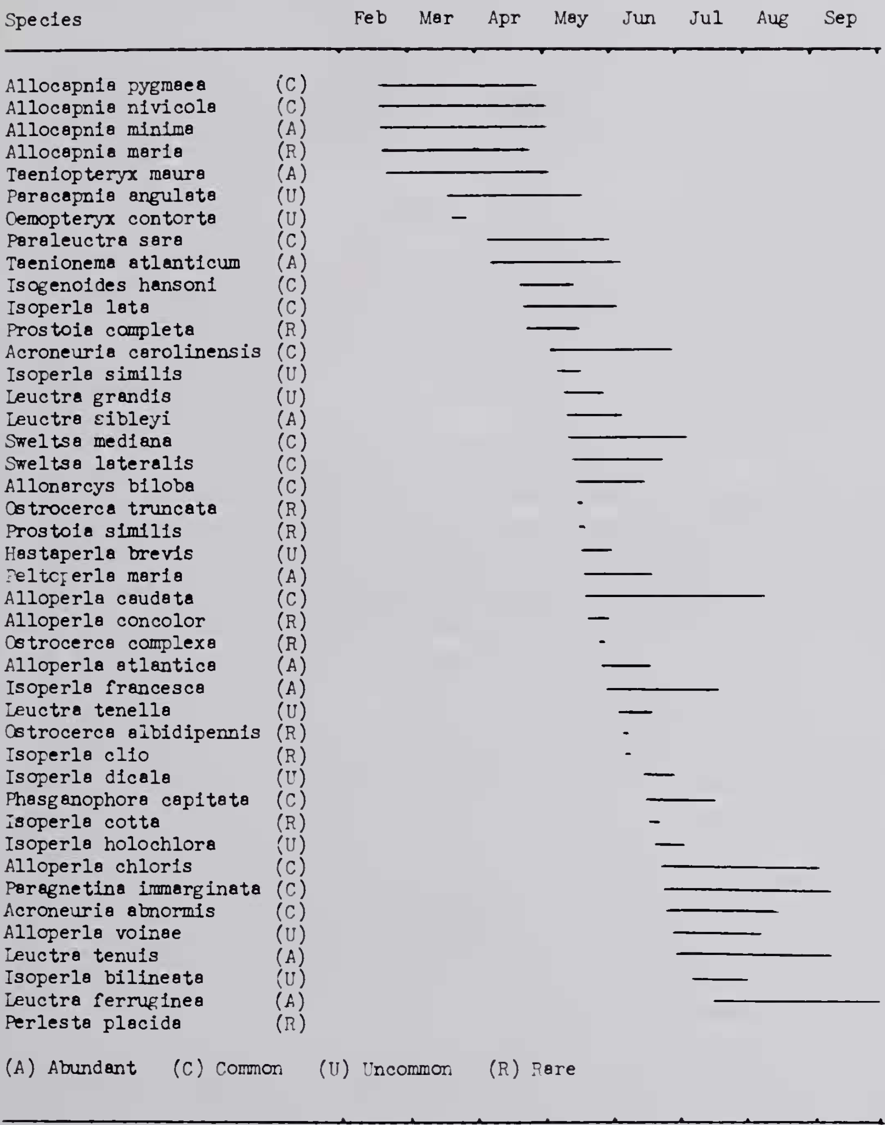

Figure 2. Seasonal occurrence of adult Plecoptera along Factory Brook, 1974 to 1976.

males. The slightly earlier emergence of males (Brink 1949; Nebeker 1971) and shorter adult life made their presence a better indicator of emergence times for each species. Emergence periods for species captured as nymphs on the non-drying adhesive agreed closely with male collection records.

Segregation of congeneric species by sequential emergence (Harper and Pilon 1970) had exceptions in several genera. *Allocapnia*, *Isoperla*, and *Al-*

Table 2. Stonefly surveys of various streams in North America.

Stream	Latitude	Number of Species	Investigator
Sashin Creek, Alaska	56′20N	17	Ellis 1975
Kananaskis River, Alta.	50′00N	37	Radford & Hartland-Rowe 1975
L'Achigan River, Que.	46′30N	50	Harper 1976
Pine-Popple River, Wis.	45′50N	34	Hilsenhoff et al. 1972
Oak Creek, Oreg.	44′30N	43	Kerst & Anderson 1974
Hubbard Brook, N.H.	44′00N	42	Fiance 1977
Factory Brook, Mass.	42′20N	45	This study
Sagehen Creek, Calif.	39′30N	31	Sheldon & Jewett 1967
Gunnison River, Colo.	38′30N	34	Knight & Gaufin 1966
Salt River, Ky.	38′00N	12	White 1974

loperla exhibited concurrent emergence of sibling species and supported previous emergence trap and rearing studies (Radford and Hartland-Rowe 1971; Narf and Hilsenhoff 1974). Reproductive isolation by genital incompatibility or behavioral mechanisms may be as effective in assuring species identity as temporal separation. Seasonal occurrence of adults fell into two basic types, synchronized and prolonged (Corbet 1964; Harper and Pilon 1970). Since the ecologically distinct phases of species with complex life cycles evolve independently (Istock 1967), short emergence periods would increase the chances of adult intra-specific contact. Macan (1958) and Corbet (1964) reviewed other possible causes and consequences of synchronized emergence. Conversely, it is advantageous for carnivorous immatures to have a wide size distribution and exploit the range of prey available (Hynes 1961). The extended emergence of many perlids, perlodids, and chloroperlids may therefore be related to the predacious habits of their nymphs. This ecological strategy to reduce competition and increase nymphal population size can also serve as a means of habitat partitioning (Kerst and Anderson 1974, 1975).

The 45 species collected from Factory Brook appear typical of stonefly diversity in undisturbed streams of north temperate latitudes (Table 2). In spite of differences in stream size and sampling effectiveness among these surveys, the general trend is for maximum stonefly diversity to occur in north temperate streams, with decreasing species numbers north and south of the temperate zone in North America. Additional surveys in the southern U.S. and Canada are required to confirm this continental diversity gradient for Plecoptera. A valid comparison between rheophilic insect diversity in mid-latitude versus tropical streams (Stout and Vandermeer 1975; Fox 1977) must await comparable tropical stream surveys to resolve this apparent exception to the diversity-latitudinal gradient rule (Pianka 1966).

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Footnote

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